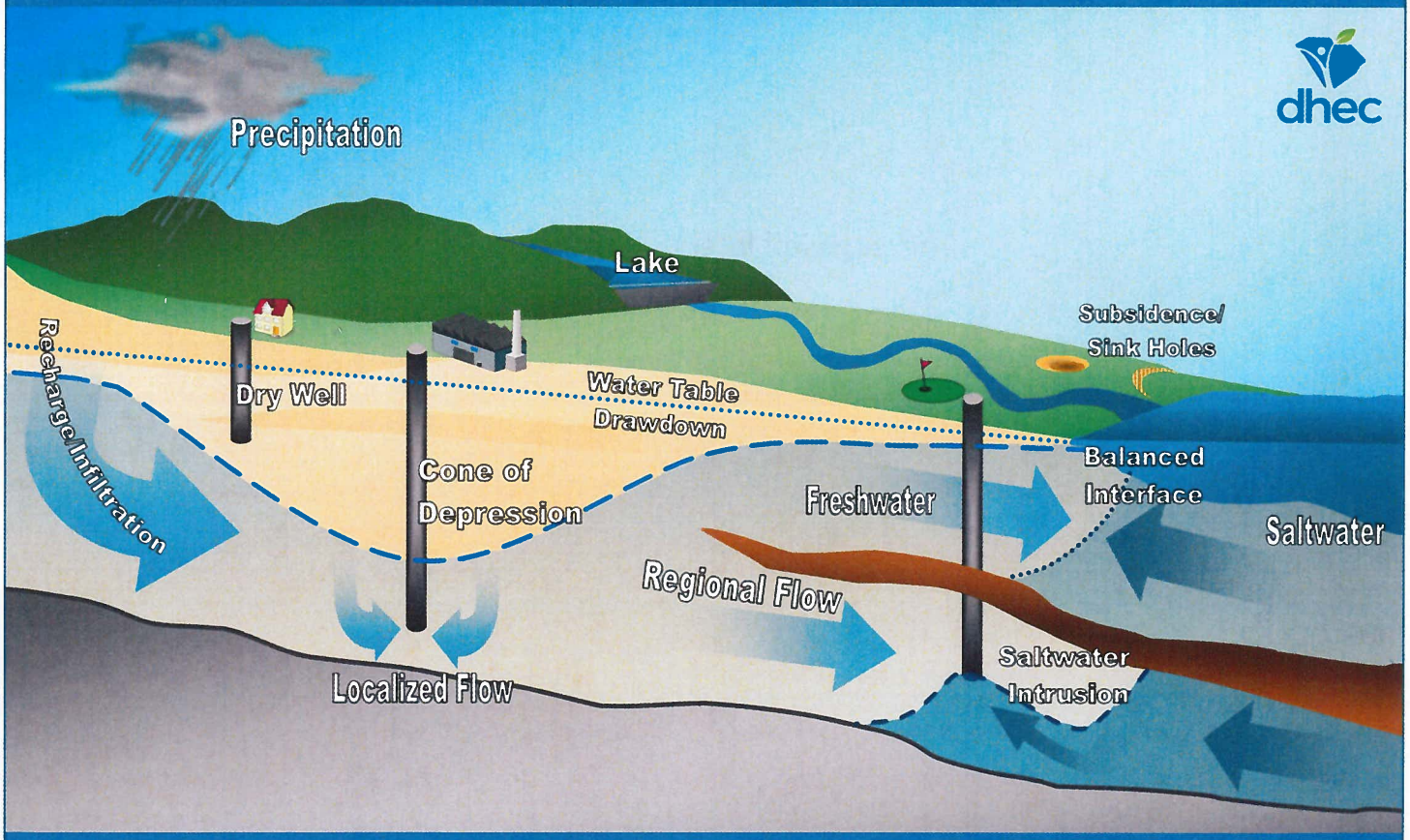
S.C. Department of Health and Environmental Control

Waccamaw Capacity Use Area: Groundwater Evaluation



Renewal Year 2019

Prepared by: Andrea L. H. Hughes, PhD, Hydrogeologist
Lance Foxworth, Hydrogeologist

January 2019

Cover Art by: Lance Foxworth

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S.C. Department of Health and Environmental Control

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Renewal Year 2019

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Technical Report Number: 0117-19

January 2019

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S.C. Department of Health and Environmental Control

Waccamaw Capacity Use Area: Groundwater Evaluation

Renewal Year 2019

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Introduction

The Waccamaw Capacity Use Area (Waccamaw Area) was the first section of South Carolina's Coastal Plain to receive the Capacity Use Designation on June 22, 1979 (S.C. Code Ann. § 49-5-60[1]). It includes Georgetown and Horry Counties (Fig. 1). In the parts of the state designated as a Capacity Use Area, a groundwater withdrawer is defined as *a person withdrawing groundwater in excess of three million gallons during any one month from a single well or from multiple wells under common ownership within a one-mile radius from any one existing or proposed well* (S.C. Code Ann. § 49-5-30[1]). In compliance with this regulation, owners of these large capacity wells are required to apply for a groundwater withdrawal permit and report their water use to the agency each year.

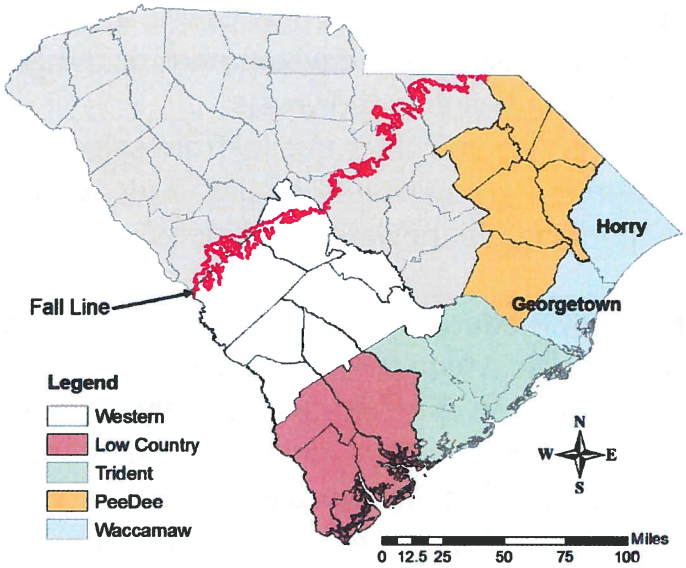


Figure 1: Map of Capacity Use Areas

Regulatory History

In 1967, the S.C. Water Resources Planning and Coordination Act (Water Resources Act) established the S.C. Water Resources Commission (the Commission), which designated the Waccamaw Area in 1979. At that time, a Groundwater Management Plan (GWMP) was not part of the Water Resources Act. In 1993, under the South Carolina Water Resources Planning and Coordination Act, the responsibilities of the Commission were distributed to SC DHEC and the SC Department of Natural Resources, and the Commission was dissolved. In 2000, the South Carolina Code of Law changed to include what is now the current Groundwater Use and Reporting Act (S.C. Code Ann. § 49-5-20 (2000)). Significant changes enacted by the new law were 1) groundwater assessments to determine the necessity of establishing a Capacity Use Area could be initiated by SC DHEC as well as requested by local governments or non-governmental organizations within the state; and 2) a GWMP was now required for each Capacity Use Area. The Waccamaw Area and the Low Country Capacity Use Area were already established, and research began to designate Dorchester, Berkeley, and Charleston Counties as the Trident Capacity Use Area (designated in 2002) as well as to designate Darlington, Dillon, Florence, Marion, Marlboro, and Williamsburg Counties as the Pee Dee Capacity Use Area (designated in 2004).

The Initial Groundwater Management Plan for the Waccamaw Capacity Use Area[2] (GWMP) was approved by the SC DHEC Board of Directors in August 2017. The three stated goals of the Waccamaw GWMP are to:

- Ensure sustainable development of the groundwater resource by management of groundwater withdrawals;
- Protect groundwater quality from salt-water intrusion;
- Monitor groundwater quality and quantity in an ongoing effort to evaluate changing groundwater conditions.

The GWMP addressed achieving these goals by assessing the following aspects of groundwater use in the Waccamaw Area:

- Groundwater sources currently utilized;
- Current water demand type and amount;
- Current aquifer storage and recovery, and water reuse;
- Population and growth projections;
- Water demand projections;
- Projected opportunities for aquifer storage and recovery, as well as water reuse;
- Water conservation measures.

Following the guidelines set forth in the GWMP, this document provides an evaluation of current groundwater use and recommendations for its management going forward.

Hydrogeologic Framework

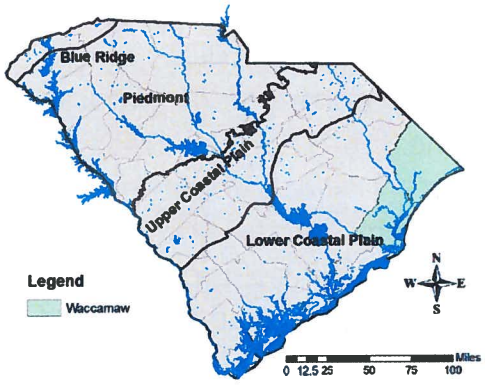


Figure 2: Physiographic Provinces of South Carolina. The Waccamaw Capacity Use Area counties are highlighted in green.

The Waccamaw Area is part of the Lower Coastal Plain physiographic province of South Carolina (Fig. 2) and has both groundwater and surface water sources. The Coastal Plain of South Carolina is part of the larger Atlantic Coastal Plain with stratigraphy marked by alternating layers of water-bearing, permeable sand or carbonate rock (aquifers) with fine-grained clays, silts, or low-permeability carbonate rock (confining units)[3] (Fig. 3).

Aquifers

The aquifers of South Carolina underlying the Waccamaw Area were deposited during the late Cretaceous to Tertiary Periods. From oldest to youngest, the Cretaceous aquifers are the Gramling, Charleston, McQueen Branch, and Crouch Branch. The Tertiary aquifers are the Gordon, Floridan, and Surficial (Fig. 3). The Floridan aquifer is minimally present below the Waccamaw area in the southern most portion of Georgetown County[3].

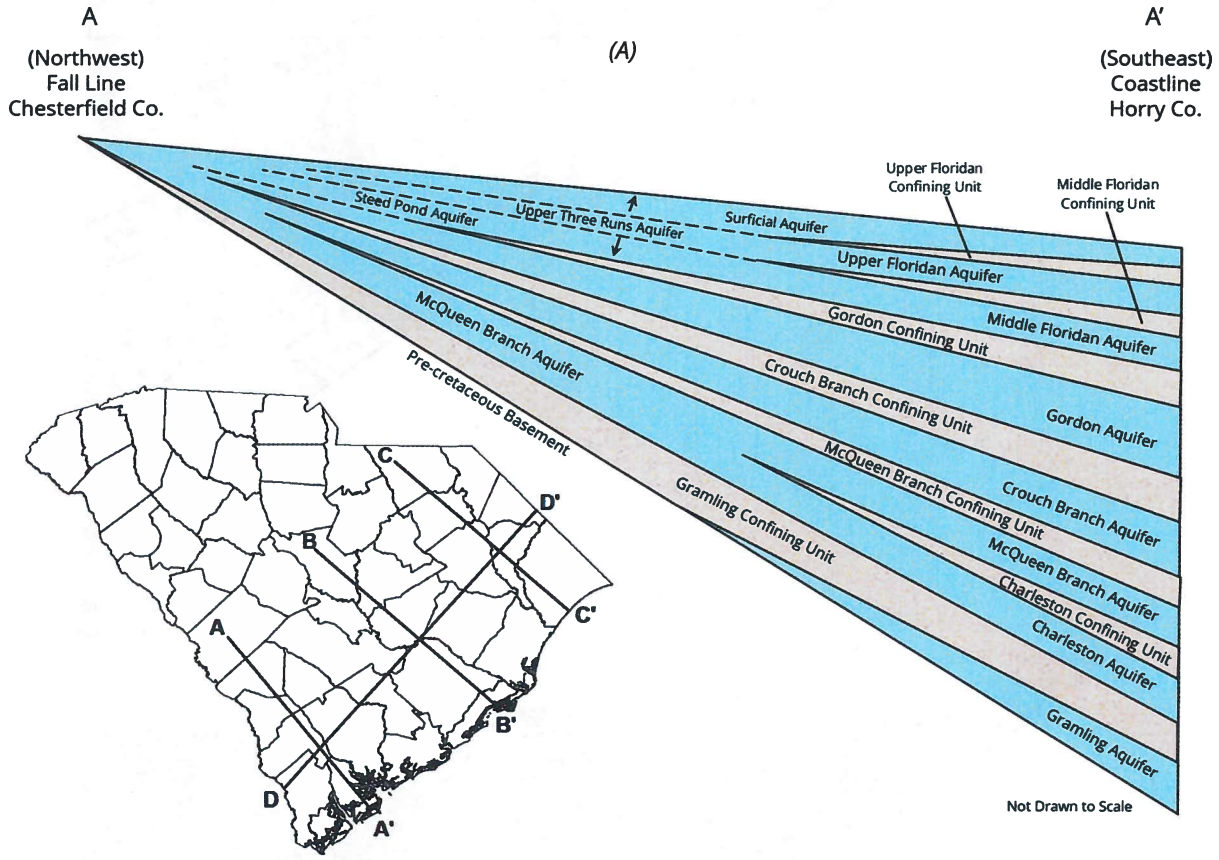


Figure 3(A) – (D): General Structure of aquifers and confining units in the South Carolina Coastal Plain. Modified from Campbell, B.G., and A.L. Coes, eds. (2010)[3]. Inset map in Fig. 3(A) shows the locations of the cross-sections.

Fig. 3(B)

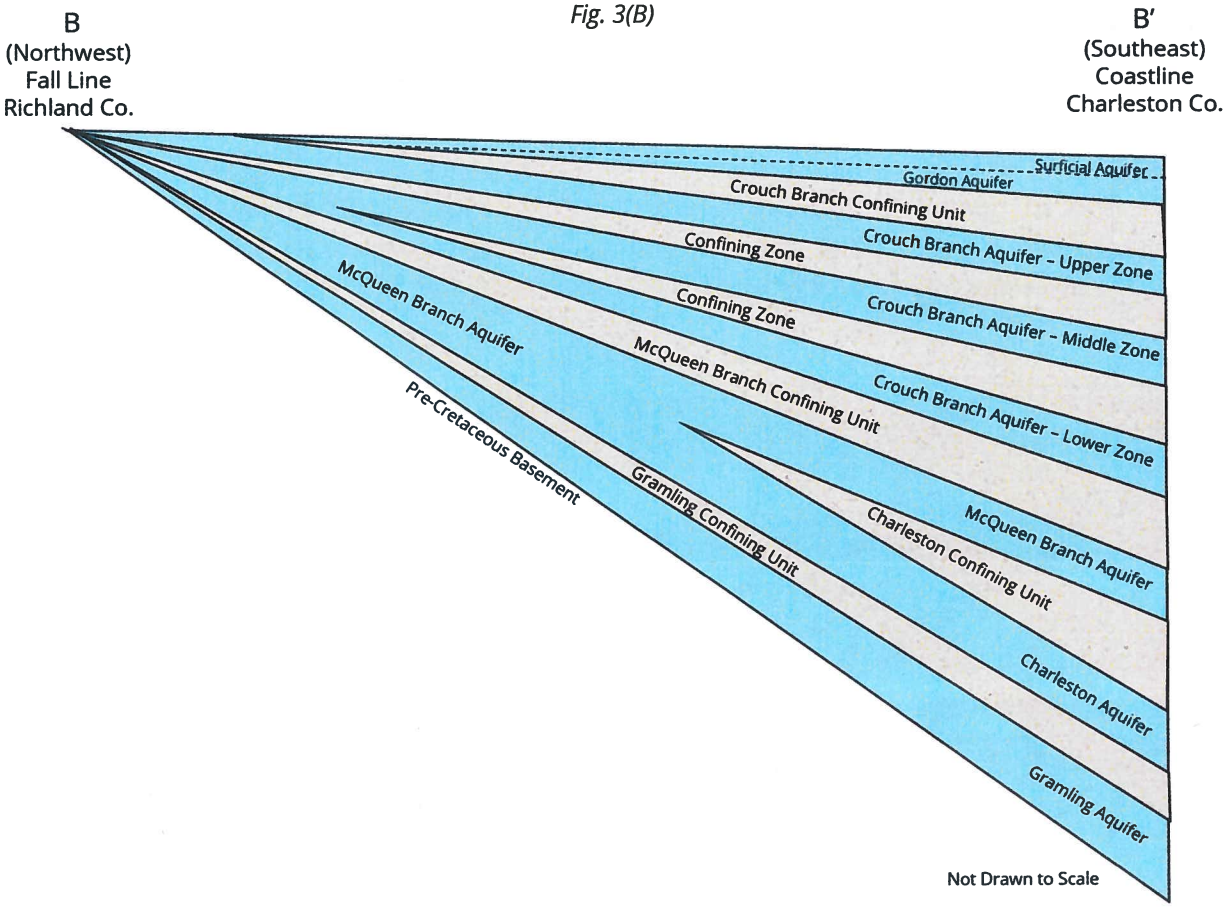
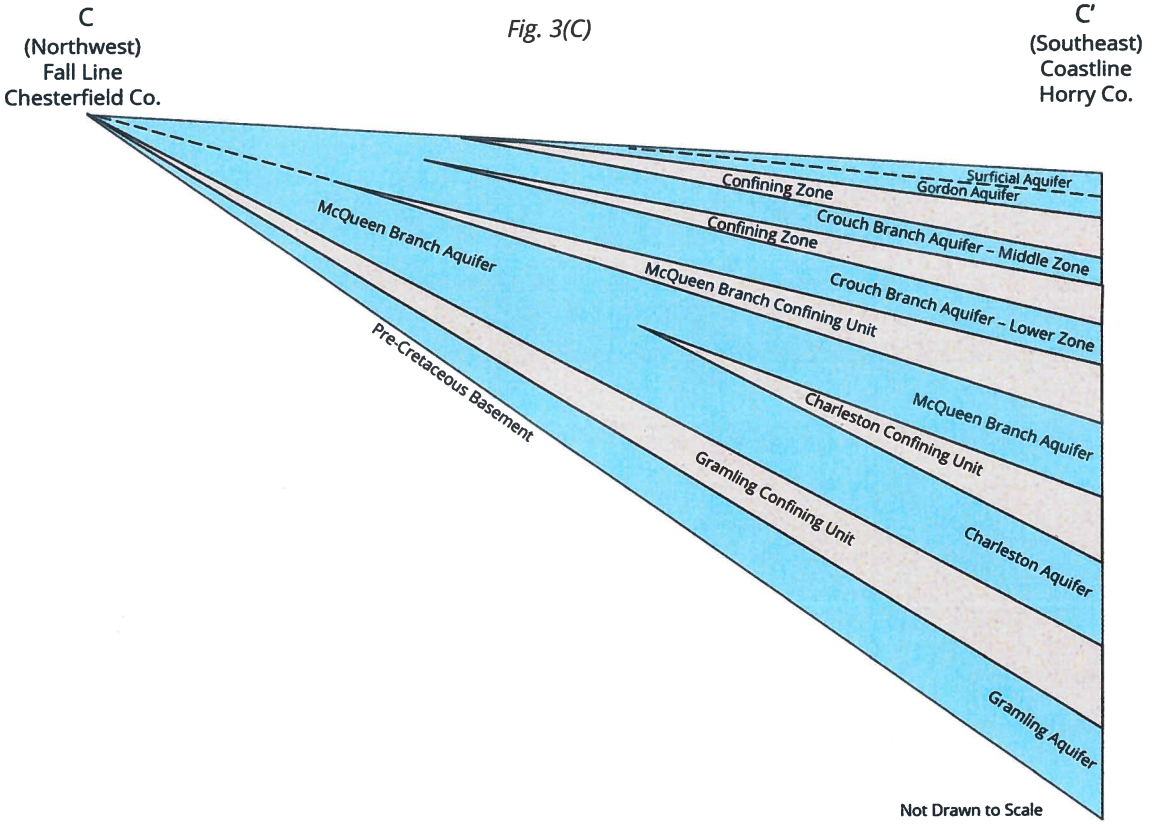
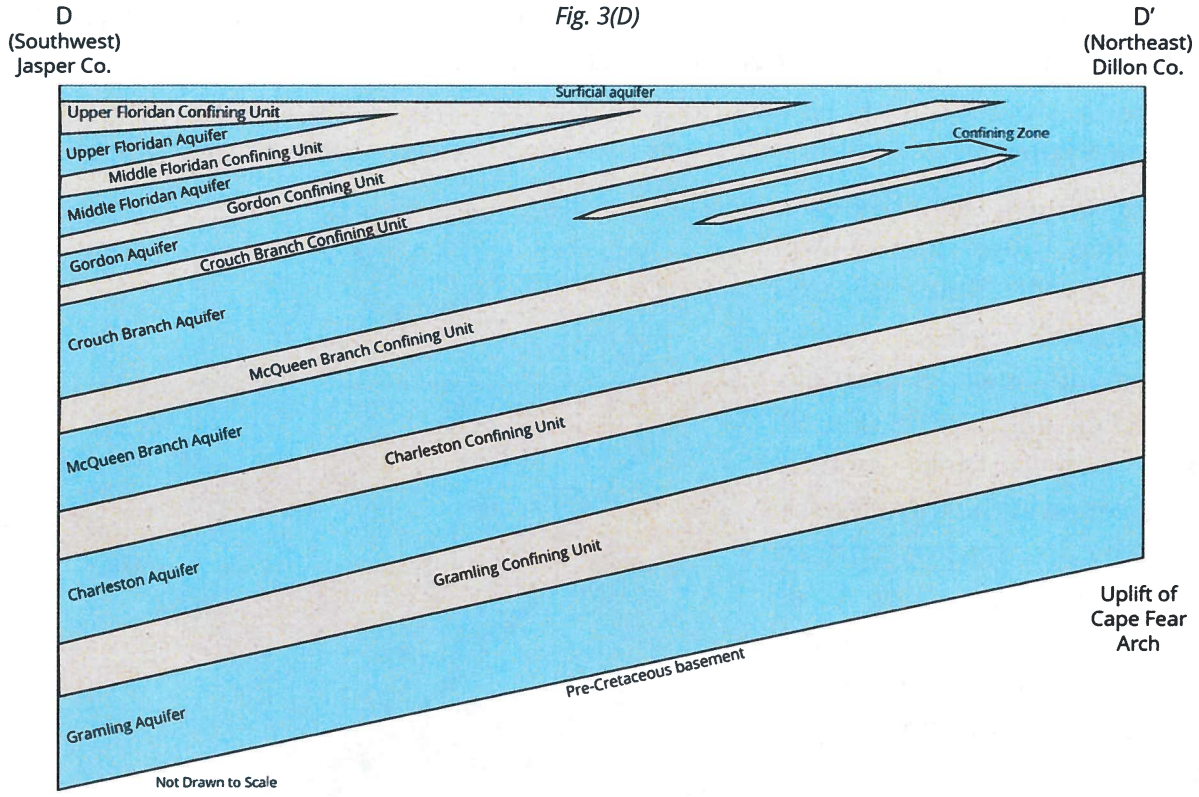

B
(Northwest)
Fall Line
Richland Co.
B'
(Southeast)
Coastline
Charleston Co.
Surficial Aquifer
Gordon Aquifer
Crouch Branch Confining Unit
Crouch Branch Aquifer – Upper Zone
Confining Zone
Crouch Branch Aquifer – Middle Zone
Confining Zone
Crouch Branch Aquifer – Lower Zone
McQueen Branch Aquifer
McQueen Branch Confining Unit
McQueen Branch Aquifer
Pre-Cretaceous Basement
Charleston Confining Unit
Gramling Confining Unit
Charleston Aquifer
Gramling Aquifer
Not Drawn to Scale

Fig. 3(C)


C
(Northwest)
Fall Line
Chesterfield Co.
C'
(Southeast)
Coastline
Horry Co.
Surficial Aquifer
Gordon Aquifer
Confining Zone
Crouch Branch Aquifer – Middle Zone
Confining Zone
Crouch Branch Aquifer – Lower Zone
McQueen Branch Aquifer
McQueen Branch Confining Unit
McQueen Branch Aquifer
Pre-Cretaceous Basement
Charleston Confining Unit
Gramling Confining Unit
Charleston Aquifer
Gramling Aquifer
Not Drawn to Scale



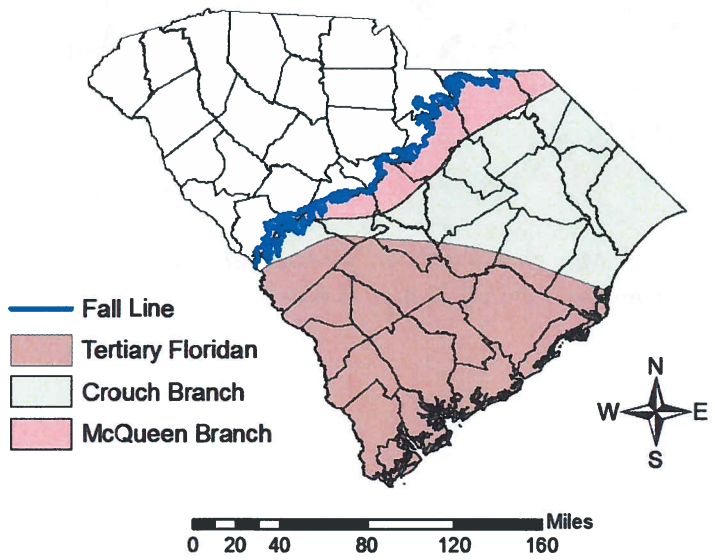


Figure 4: Map of Aquifer Recharge areas.

The recharge areas for these aquifers are generally within the Upper Coastal Plain (Fig. 4). For the Waccamaw area, that means that the surficial aquifer is the only aquifer that receives direct recharge through infiltration of local precipitation. Groundwater in the deeper aquifers is replenished by precipitation that infiltrates in the Upper Coastal Plain and then moves slowly 'down dip'. Consequently, the rate at which groundwater is replenished in the deeper aquifers of the Waccamaw area is controlled by the rate at which groundwater travels from the recharge zones close to the Fall Line. Typical groundwater flow rates for silts to well-sorted sands range from 0.003 to 300 feet per day[4]. This means that once the precipitation becomes part

of the groundwater, it may take from a few years to tens of thousands of years to reach the aquifer locations below the Waccamaw Area.

Surface Water

The Waccamaw, Little Pee Dee, Great Pee Dee, Black, and Santee Rivers flow through Georgetown and Horry Counties, as well as partially define their boundaries (Fig. 5). These rivers, their smaller tributaries, and the Intracoastal Waterway are used as primary water sources or as alternatives to groundwater sources in these counties. In contrast to other regions of the state, there are no major lakes (e.g. Lakes Marion and Moultrie) in the Waccamaw Area.

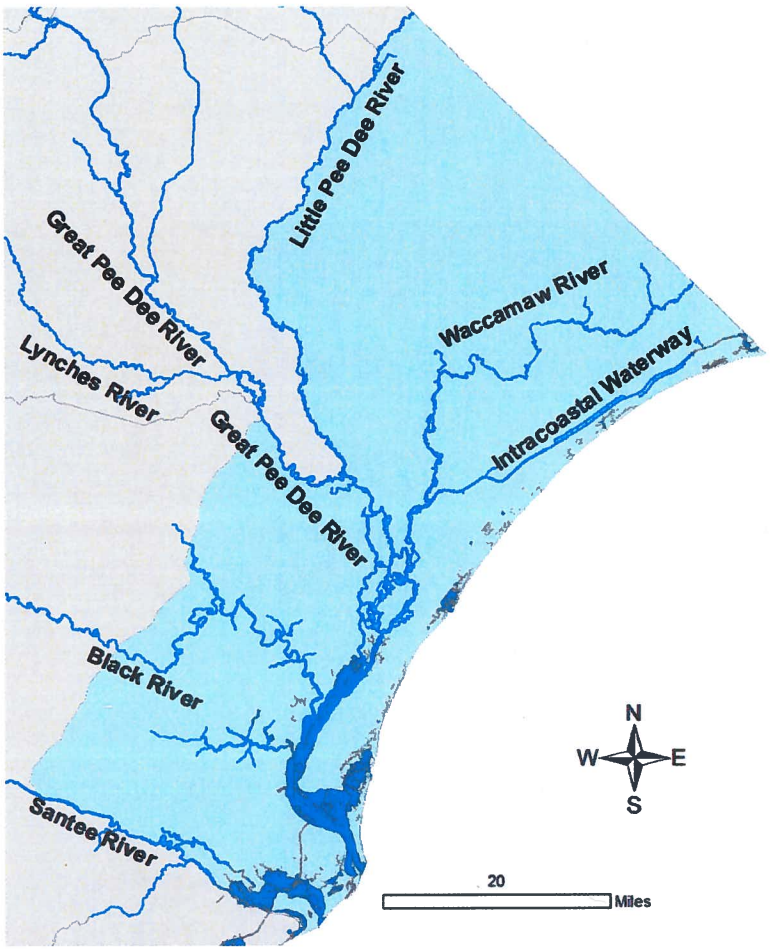


Figure 5: Map showing the major rivers entering the Waccamaw Area (highlighted in blue).

Groundwater Trends

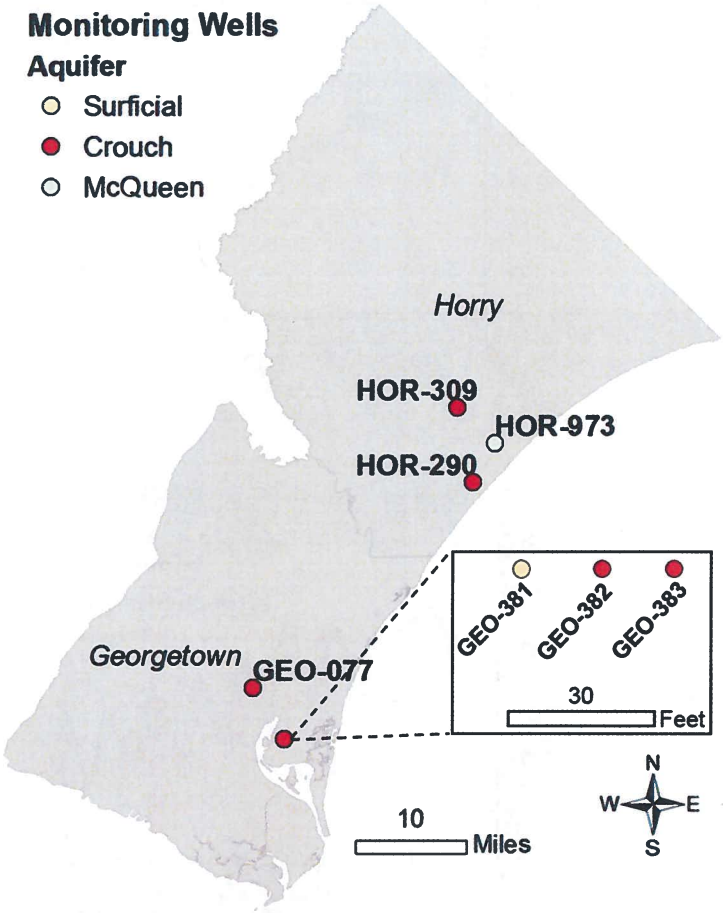
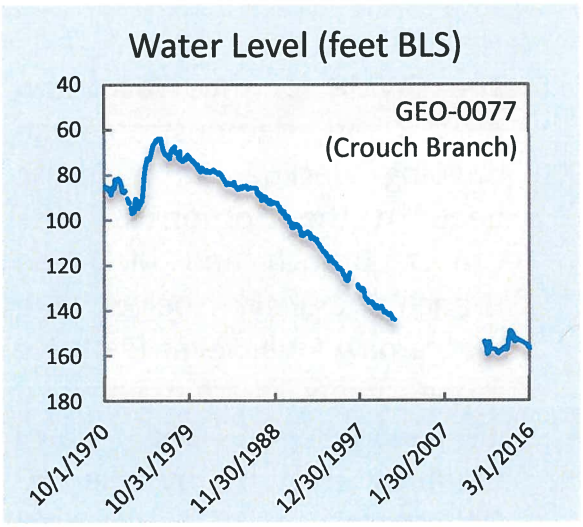
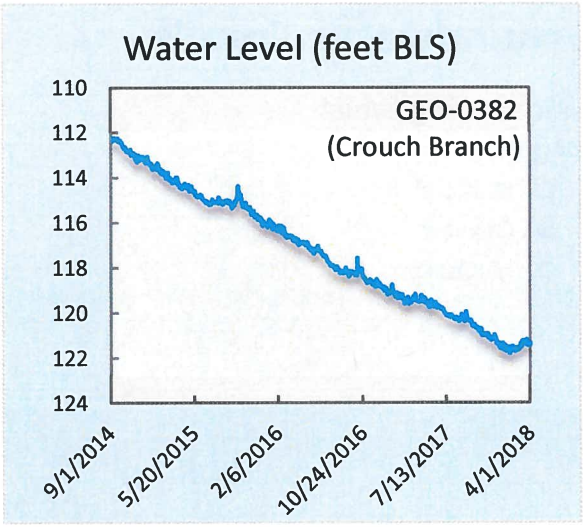


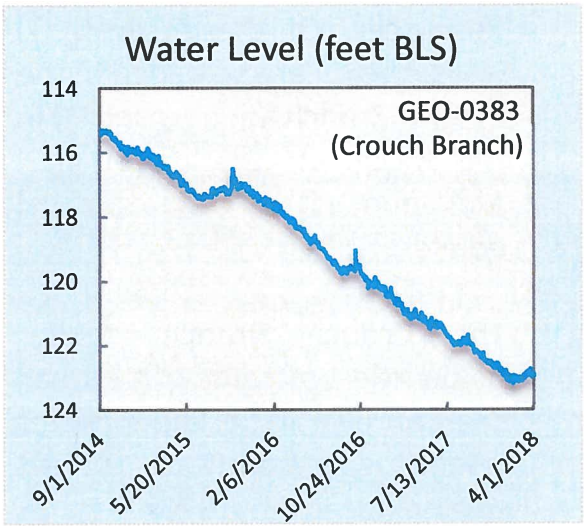
Figure 6: Map of Georgetown and Horry Counties showing the locations of the SC Department of Natural Resources' monitoring wells. The pop-out box shows the details the locations of wells GEO-381, GEO-382, and GEO-383.

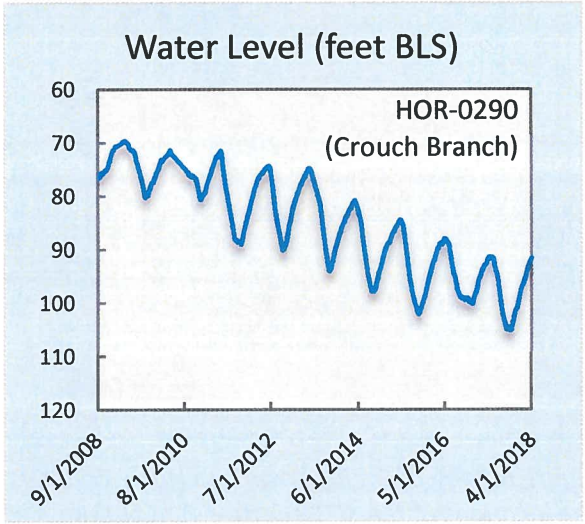
The GWMP for the Waccamaw Area[2] clearly demonstrated the ongoing decline in hydraulic head in the portions of the Crouch Branch and McQueen Branch Aquifers below the Waccamaw Area. Seven (7) active monitoring wells are maintained in Georgetown and Horry Counties (Fig. 6) by the SC Department of Natural Resources. Of these seven (7) wells, five (5) are screened in the Crouch Branch aquifer, one (1) in the McQueen Branch aquifer, and one (1) in the surficial aquifer.

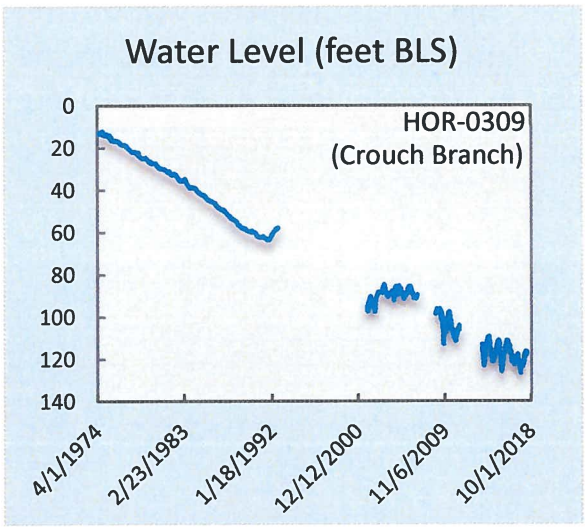
The Crouch Branch aquifer below the Waccamaw Area has seen an overall decline in water level ranging from 7 to 100 feet beginning in the 1970s (Fig. 7). The measurements from the monitoring well screened in the McQueen Branch aquifer (HOR-0973) show a rebound in water level of nearly 10 feet since 1998 at that location.











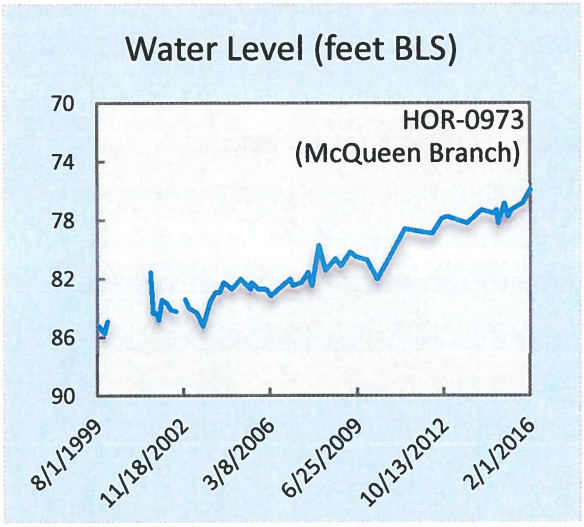


Figure 7: Continuous water level measurements from SC Dept. of Natural Resources Monitoring Wells. Well locations are shown in Figure 6. Water levels are given in feet below land surface (BLS).

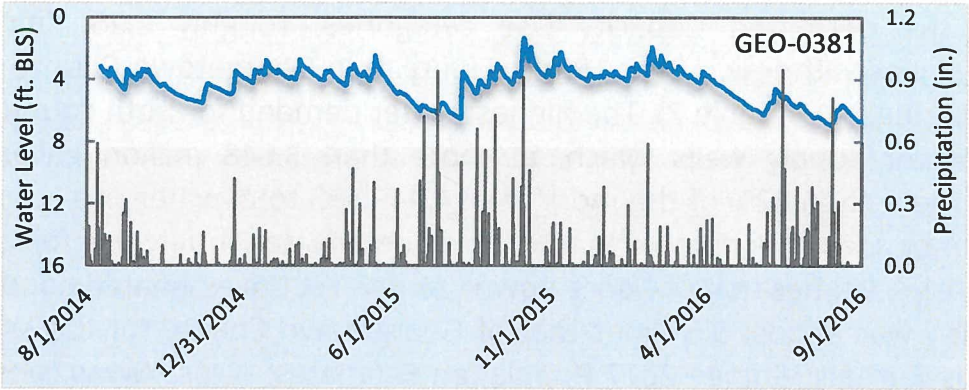


Figure 8: Water level measurement data from Georgetown County well GEO-0381 screened in the shallow surface aquifer. Precipitation data obtained from meteorology station located at the Oyster Landing dock at the Belle Baruch Marine Field Laboratory (http://cdmo.baruch.sc.edu/; accessed 10/16/2018).

The water level profile for the surficial aquifer well (GEO-0381) contrasts with those of the deeper, confined aquifers based on differences in recharge. The water level in the surficial aquifer is impacted by direct recharge from rainfall events (from weeks to months) and seasonal variations in evapotranspiration (increases in the summer, decreases in the winter) (Fig. 8).

Current Groundwater Demand

The Waccamaw Area currently has 223 permitted Capacity Use wells (Table 1, Fig. 9). Nearly half of the 223 wells are permitted for public water supply, and more than three-quarters of the wells are within Horry County. The majority of wells within Georgetown County are for public water supply (78%), but the number of golf course wells exceeds water supply wells in Horry County (45% versus 36%).

Table 1: Number of Capacity Use Wells by Type and County

Water Use Category	Georgetown County	Horry County	Totals
Aquaculture (AQ)	0	0	0
Golf Course (GC)	2	78	80
Industry (IN)	8	3	11
Agricultural Irrigation (IR)	1	13	14
Mining (MI)	0	0	0
Hydro Power (PH)	0	0	0
Thermo Power (PT)	0	0	0
Nuclear Power (PN)	0	0	0
Water Supply (WS)	39	63	102
Other (OT)	0	16	16
TOTAL	**50**	**173**	**223**

Across all the permitted Capacity Use categories, roughly 2.25 times more groundwater was withdrawn from Horry County than Georgetown County Capacity Use Wells during 2017 (Table 2). The highest water demand for both counties came from the water supply wells which, at more than 3,648 million gallons (MG), comprised more than 82% of the more than 4,443 MG total water use reported for the Waccamaw Area. It is notable that Horry County water supply use for 2017 was approximately 1.9 times that of Georgetown County. Yet the estimated population of Horry County was almost 5.5 times that of Georgetown County for the same year (U.S. Census Bureau, Vintage 2017 Population Estimates; https://www.census.gov/; accessed 11/4/2018).

Table 2: 2017 Reported Water Use by Permit Category

Water Use Category	Georgetown County (MG)	Horry County (MG)	Use Totals (MG)	Percent of Total
Aquaculture	0	0	0	0%
Golf Course	0	483	483	11%
Industry	105	0	105	2%
Agricultural Irrigation	0	207	207	5%
Mining	0	0	0	0%
Hydro Power	0	0	0	0%
Thermo Power	0	0	0	0%
Nuclear Power	0	0	0	0%
Water Supply	1,263	2,386	3,649	82%
Other	0	1	1	<0.1%
TOTAL	1,368	3,077	4,445	100%
Percent of Total	31%	69%	100%	

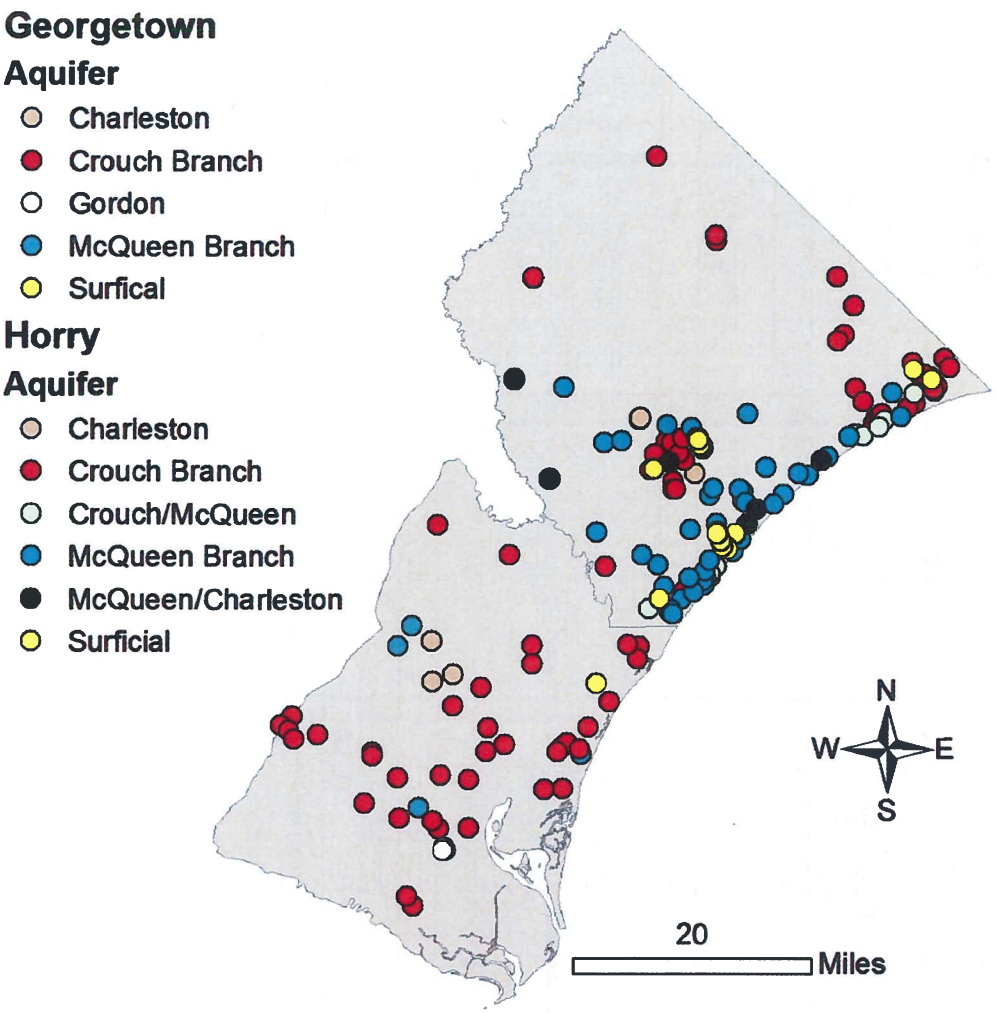


Figure 9: Map of currently active Capacity Use Wells by Aquifer – Waccamaw Area. NOTE: there are several wells in Horry County which were screened across two (2) aquifers.

Georgetown County Demand Details

There are currently 12 permitted facilities that own a total of 50 wells in Georgetown County. Table 3, below, lists the permit numbers, permitted withdrawal rates (in MGY or millions of gallons per year), 2017 reported water use (in MG used during that year), and the aquifer(s) into which the wells for each facility are screened. The reported withdrawals for 2017 were 61% of the permitted annual withdrawal limits. The Crouch Branch aquifer was the source of the largest groundwater withdrawals at 82% (1,117.771 MG) of the total reported for 2017, followed by the McQueen Branch aquifer at 11.5% (158.98 MG), the Charleston aquifer at 5% (69.497 MG), and the Gordon aquifer at 1.5% (21.394 MG).

Table 3: Current Permitted Capacity Use Groundwater Withdrawers - Georgetown County.

Facility	Permit	Aquifer(s)	Permit Amount (MGY)	2017 Reported Water Use (MG)
Founders Club	22GC006	Crouch Branch	70	0
Pawley's Plantation	22GC011	McQueen Branch	50	0
3V Sigma USA	22IN001	McQueen Branch	145	79.71
Santee Cooper – Winyah Station	22IN002	Crouch Branch	5	0
International Paper Santee Woodyard	22IN008	Gordon	60	21.394
Interfor	22IN052	Crouch Branch	36	3.892
Plantersville Turf Farms	22IR038	Crouch Branch	25.2	0
Georgetown County Water & Sewer District	22WS001	Surficial, Crouch Branch, McQueen Branch	1,024	Surficial: 0 Crouch Branch: 603.138 McQueen Branch: 79.27
City of Georgetown	22WS002	Crouch Branch	195.95	169.516
Georgetown Rural Community Water District	22WS003	Crouch Branch	258	152.863
Town of Andrews	22WS004	Crouch Branch	300	188.362
Brown's Ferry Water Co.	22WS007	Charleston	76.698	69.497
		TOTAL	**2,245.398**	**1,367.642**

NOTE: MGY is the currently permitted annual withdrawal rate (Million Gallons per Year) issued to the Facility and MG is the total amount of water (Million Gallons) used during 2017 as reported by the Facility.

Horry County Groundwater Demand Details

There are currently 38 permitted facilities that own 174 wells in Horry County. Table 4, below, lists the permit numbers, permitted withdrawal rates (in MGY or millions of gallons per year), 2017 reported water use (in MG used during that year), and the aquifer(s) into which the wells for each facility. The reported withdrawals for 2017 were 41% of the permitted withdrawal limits. The McQueen Branch aquifer was the source of the largest groundwater withdrawals at 44% (1,341.628 MG) of the total reported for 2017, followed by the Crouch Branch at 16% (493.474 MG), the Charleston Aquifer at 16% (481.597 MG), and the surficial aquifer at 2% (49.3638 MG). There are several wells in Horry County that were screened across aquifers when constructed. Of the county's water use totals for 2017, 17% came from wells screened across the Crouch/McQueen aquifers (528.8864 MG), and 6% from wells screened across the McQueen/Charleston aquifers.

Table 4: Current Permitted Capacity Use Groundwater Withdrawers - Horry County.

Facility	Permit	Aquifer(s)	Permit Amount (MGY)	2017 Reported Water Use (MG)
Azalea Sands Golf Club	26GC001	Crouch Branch	50	7.36
Beachwood Golf Club	26GC003	Crouch Branch	65	54.577
Myrtle Beach National GC	26GC009	Surficial, McQueen Branch	55	Surficial: 11.147 McQueen Branch: 0
Possum Trot Golf Club	26GC010	Crouch Branch	60	36.642
Surf Golf & Beach Club	26GC013	Crouch Branch	90.34	72.776
Midway Par Three	26GC020	Crouch Branch	25	14.001
Pine Lakes International Country Club	26GC021	McQueen Branch	72	47.41
Eagle Nest Golf Club	26GC025	Surficial, Crouch Branch	25	Surficial: 15.75 Crouch Branch: 2.265
Tidewater Golf	26GC028	Crouch Branch	70	21.8
River Hills Golf & Country Club	26GC029	Crouch Branch	30	0.5
Heather Glen Golf Links	26GC034	Crouch Branch	54.73	10.85
City of Myrtle Beach Whispering Pines Golf Course	26GC036	Surficial	46.033	0
Valley Club at Eastport	26GC041	Surficial, Crouch Branch	24.84	Surficial: 0 Crouch Branch: 0.24
Witch Golf Links	26GC043	Surficial, Crouch Branch	25	Surficial: 0 Crouch Branch: 1.407
Legends Resorts – The Legends Course	26GC044	Crouch Branch	99	66.6
Indigo Creek Golf Club	26GC046	Surficial, Crouch Branch	36	Surficial: 21.4 Crouch Branch: 0
Harbour View LLC	26GC051	Crouch Branch	36	16.014
Glen Dornoch LLC	26GC054	Crouch Branch	70	34.51
Tupelo Bay Golf Complex	26GC055	McQueen Branch	36	23.76
International Club LLC	26GC056	Crouch Branch/ McQueen Branch	40	15.756
World Tour Golf Links	26GC058	Crouch Branch	54.5	7.82
Rose Park, LLC – Crown Park Golf Club	26GC060	Crouch Branch	36	0
Canfor Southern Pine – Conway Mill	26IN002	McQueen Branch	40.02	0

Table 4 - continued

Facility	Permit	Aquifer(s)	Permit Amount (MGY)	2017 Reported Water Use (MG)
Santee Cooper – Grainger Station	26IN007	Charleston	98.4	0
Coastal Carolina University	26IR019	Crouch Branch	36	0
Burroughs and Chapin – Broadway	26IR020	McQueen Branch	100	97.72
The Sod Farm	26IR025	Crouch Branch	50	38.5
City of Myrtle Beach	26IR026	McQueen Branch	36	1.241
Myrtle Trace HOA	26IR027	Crouch Branch	42.4	39.08
GDMB Operations LLC – Bear Branch	26IR028	McQueen Branch	130	22.6
Coastal Carolina University – Atlantic Fields	26IR034	Crouch Branch	12	7.6
Myrtle Beach AFB AFCEC	26OT020	Surficial	106	1.0468
City of North Myrtle Beach	26WS001	Crouch Branch/ McQueen Branch, McQueen Branch	453.6	Crouch Branch/ McQueen Branch: 279.906 McQueen Branch: 2.16
Bucksport Water System, Inc.	26WS002	McQueen Branch McQueen Branch/Charleston	500	McQueen Branch: 227.68 McQueen Branch/Charleston: 178.89
City of Myrtle Beach	26WS003	McQueen Branch, McQueen Branch/ Charleston	17	McQueen Branch: 4.884 McQueen Branch/Charleston: 1.0904
Ocean Lakes Family Campground	26WS005	McQueen Branch	128	95.188
Grand Strand Water & Sewer Authority	26WS009	Crouch Branch, McQueen Branch, Charleston, Crouch Branch/ McQueen Branch, McQueen Branch/ Charleston	4,661.24	Crouch Branch: 82.753 McQueen Branch: 798.405 Charleston: 481.597 Crouch/McQueen: 194.076 McQueen/Charleston: 0
Lakewood Camping Resort, Inc.	26WS011	Crouch Branch/ McQueen Branch	60	39.14836
		TOTAL	**7,535.103**	**3,076.17056**

NOTE: MGY is the currently permitted annual withdrawal rate (Million Gallons per Year) issued to the Facility and MG is the total amount of water (Million Gallons) used during 2017 as reported by the Facility.

Past Use Comparison

Horry County groundwater use has exceeded Georgetown County consistently from 2001 through 2017 (Fig. 10). The highest water use total for Georgetown was reported in 2016 (1,551.091 MG) and for Horry was reported in 2017 (3,076.171 MG). Reported water use has increased over the past 17 years for Horry County but has remained comparatively constant for Georgetown County. Both the differences in overall groundwater use and rate increases may be explained by the difference in population between the two counties (Fig. 11). The increases in population are reflected in the increases in groundwater use for Horry County over the same period while Georgetown County's population and water use have remained relatively unchanged.

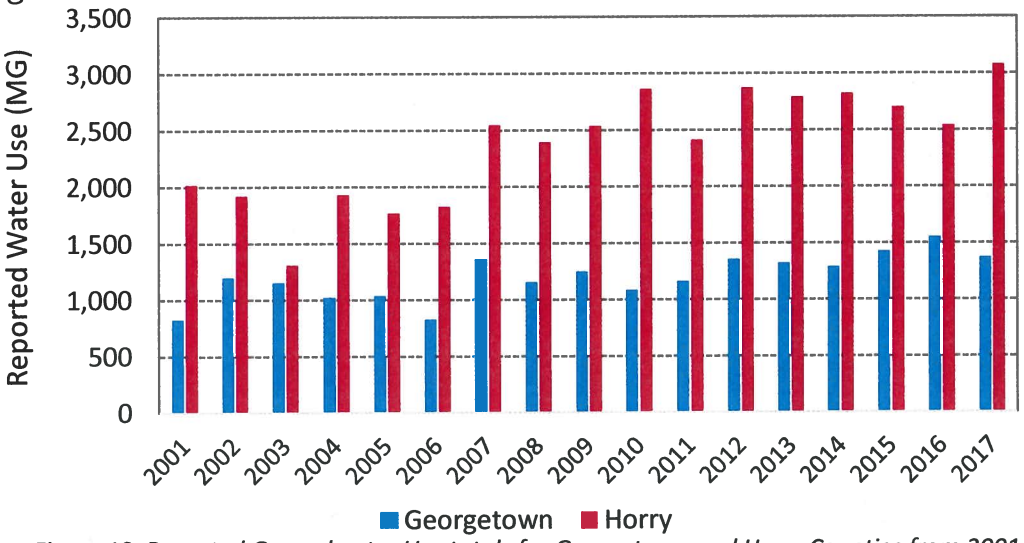


Figure 10: Reported Groundwater Use totals for Georgetown and Horry Counties from 2001 to 2017.

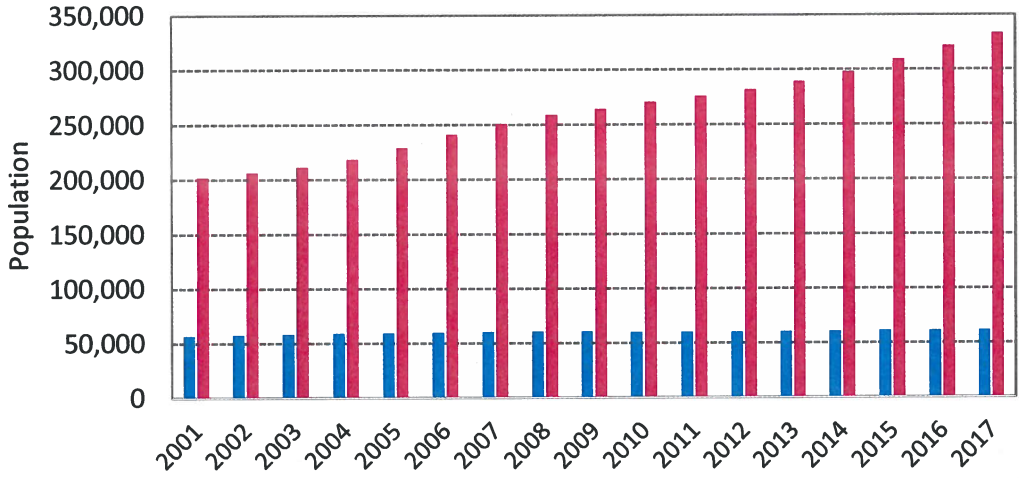


Figure 11: Population of Georgetown and Horry Counties. Census was taken in 2010, other years are U.S. Census Bureau Estimates. (https://www.census.gov/; accessed 11/4/2018)

Water supply wells have been the largest withdrawer of groundwater in the Waccamaw Area (Fig. 12). In particular, water supply wells comprise the majority of permitted groundwater withdrawal for Georgetown County. In Horry County, 2001 reported water use for golf course irrigation nearly equaled that reported for water supply. However, the demand for groundwater to irrigate golf courses has decreased steadily since 2001, while the water supply demand has increased steadily over the same period. Industrial use of groundwater has remained a small, but steady, part of groundwater demand in Georgetown County, and has decreased to nearly zero in Horry County. This reflects the reliance of industry on surface water for the majority of their manufacturing and processing needs.

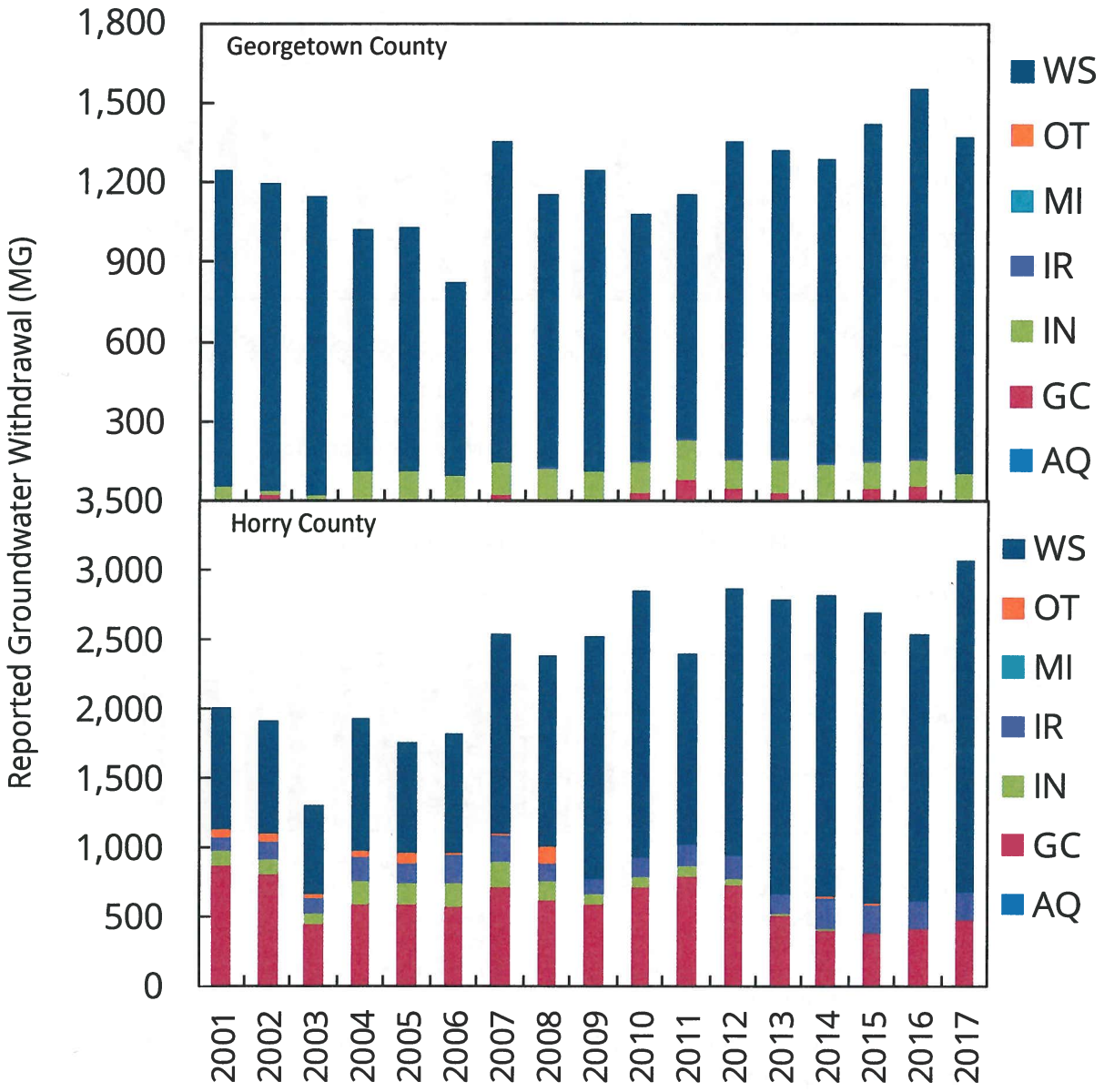


Figure 12: Reported Water Use by Use Type for Georgetown and Horry Counties from 2001 to 2017.

Aquifer Demand

Distinct differences in aquifer demand exist between the two counties of the Waccamaw Area (Fig. 13). The Crouch Branch aquifer is the most frequently utilized aquifer for permitted groundwater withdrawal in Georgetown County, far exceeding the demand on any other aquifer available. For Horry County, the Crouch Branch and McQueen branch aquifers were the most utilized aquifers in 2001. At present, the McQueen Branch is utilized most frequently followed by a fairly equal distribution of use between the Charleston, Crouch, and Crouch/McQueen aquifers.

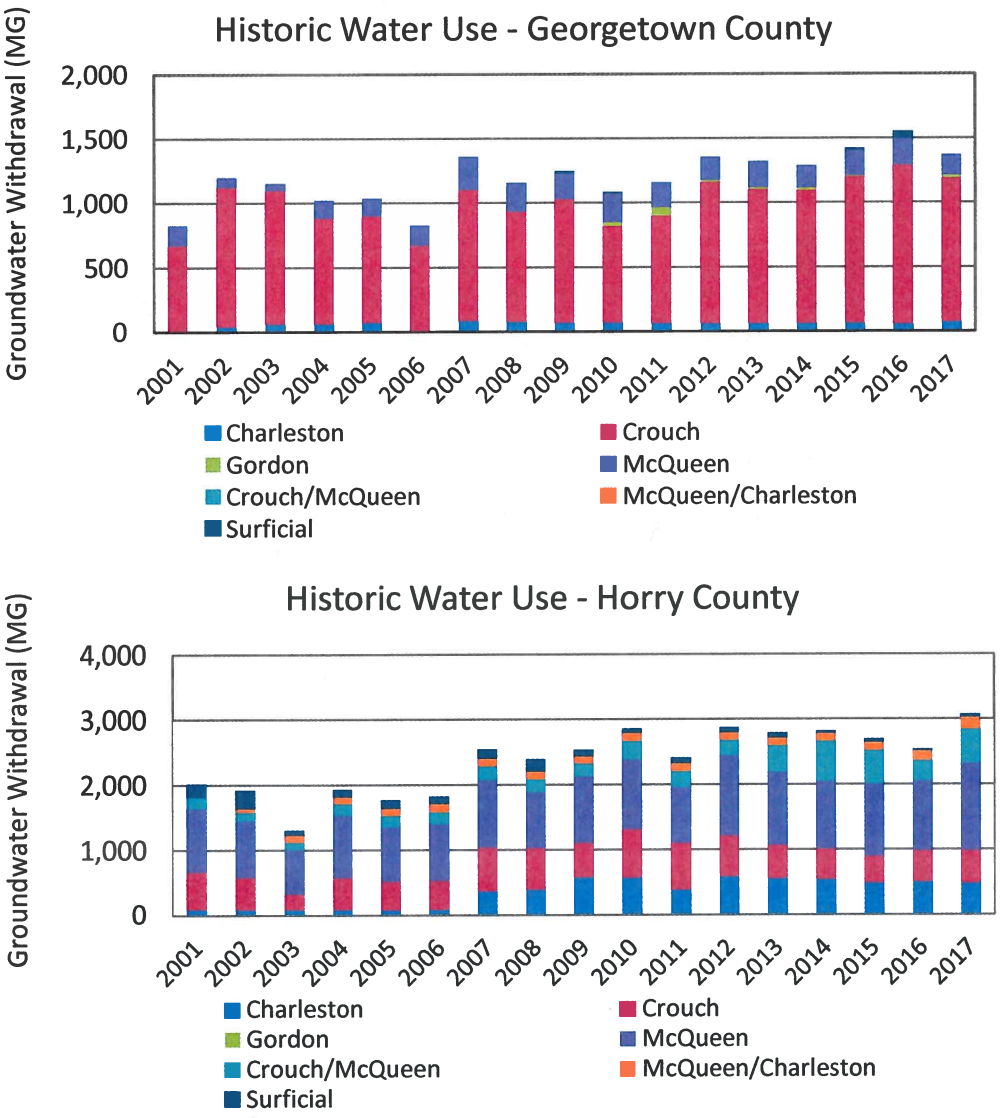


Figure 13: Reported Groundwater Use for Georgetown and Horry Counties by Aquifer from 2001 to 2017.

Waccamaw Area Cone of Depression

The reliance of groundwater withdrawers on the Crouch Branch Aquifer in Georgetown County has created an ongoing groundwater trend of concern in the Waccamaw Area. A cone of depression has developed in the Crouch Branch aquifer below Georgetown County. A cone of depression (or pumping depression) is when the water table (unconfined aquifer) or equipotential surface (confined aquifer) is lowered in the area surrounding a pumping well (Fig. 14).

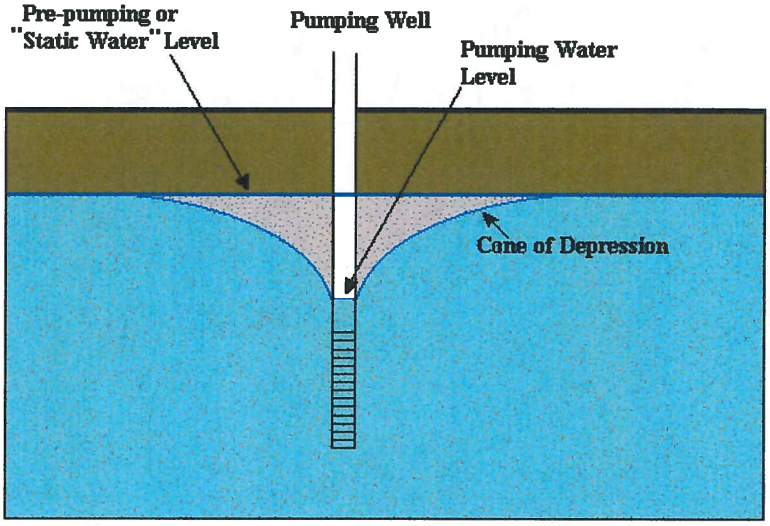


Figure 14: Illustration of the Formation of a Cone of Depression in an Aquifer.

Water level measurements revealed this cone of depression beginning in 1982, and its depth and breadth have increased to the present day. Variations in the shape and extent of this feature over a 12-year period are shown in Figures 15 – 19. In addition, these figures clearly show the relationship between groundwater withdrawals from this aquifer and the development of this pumping depression.

In 2004, the center of this low point encompassed the towns of Andrews and Georgetown (Fig. 15). By 2016, the depression was centered between Andrews and Georgetown, and the lowest measured water level was approximately 50 feet deeper than in 2004. By 2016, influence of this cone of depression had extended to the equipotential lines in the Crouch Branch aquifer underlying the nearby counties of Williamsburg, Marion, and Horry (Fig. 19).

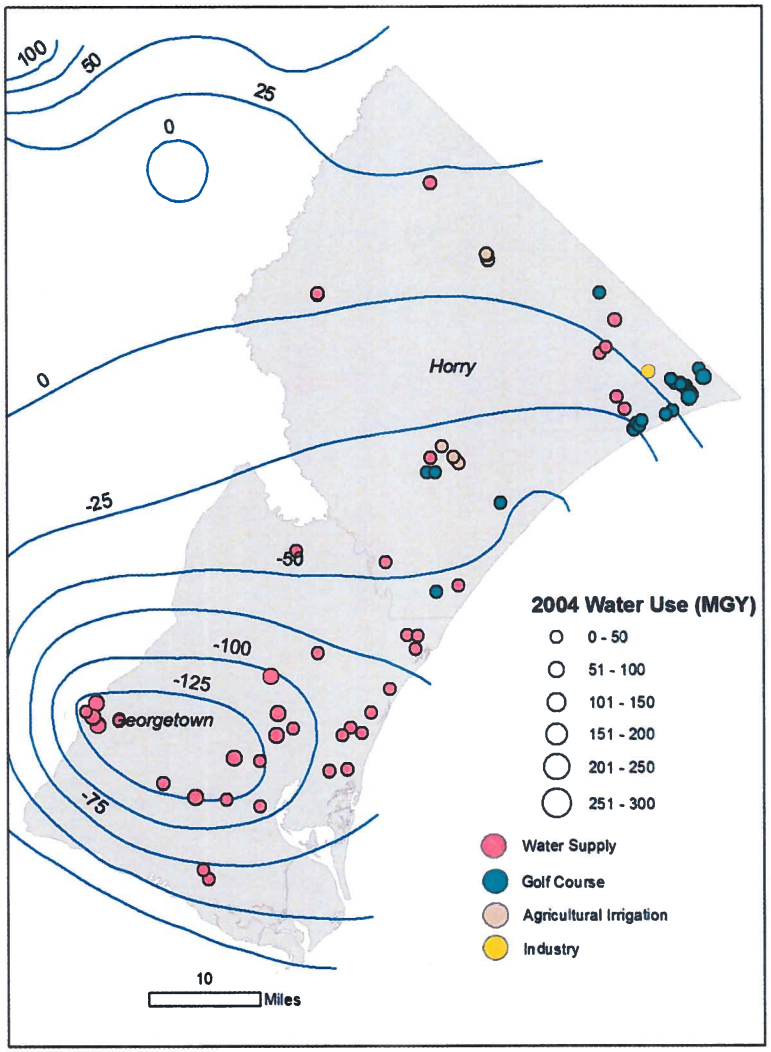


Figure 15: 2004 Reported Water Use and Equipotential Lines in the Crouch Branch aquifer. For Figures 15 – 19, well locations shown are only those for which water use was reported, circle size represents amount of groundwater withdrawn in millions of gallons, and the color of the circle represents the water use category. [Equipotential Lines: lines of equal groundwater elevation]

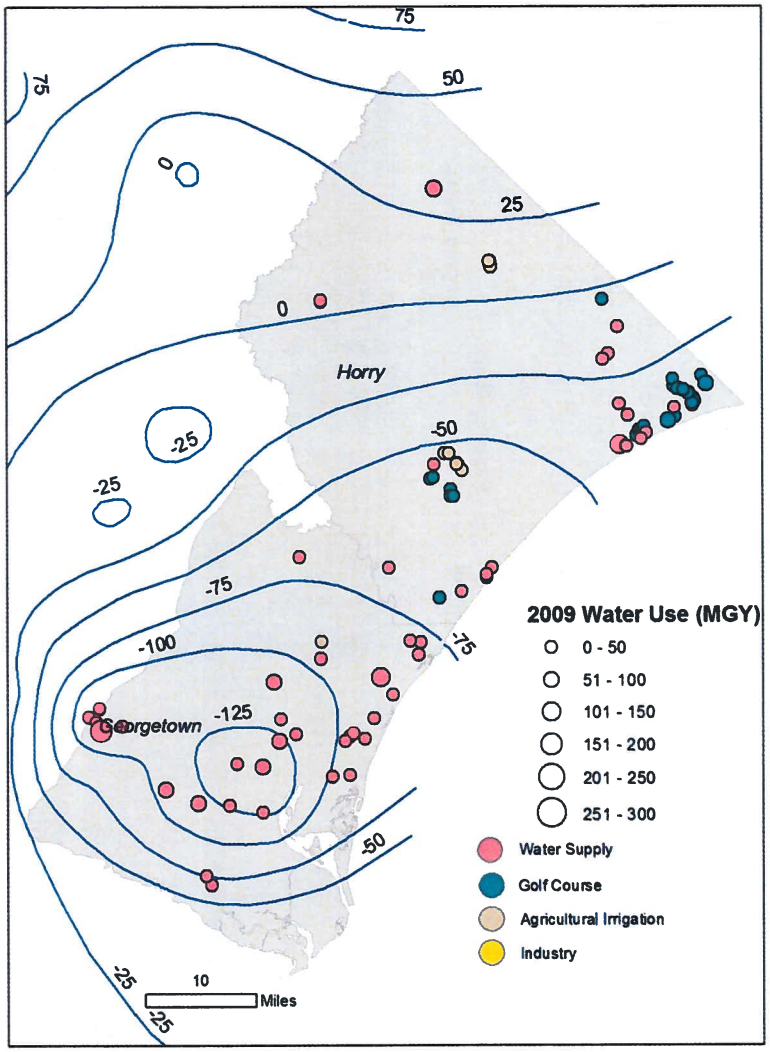


Figure 16: 2009 Reported Water Use and Equipotential Lines in the Crouch Branch aquifer.

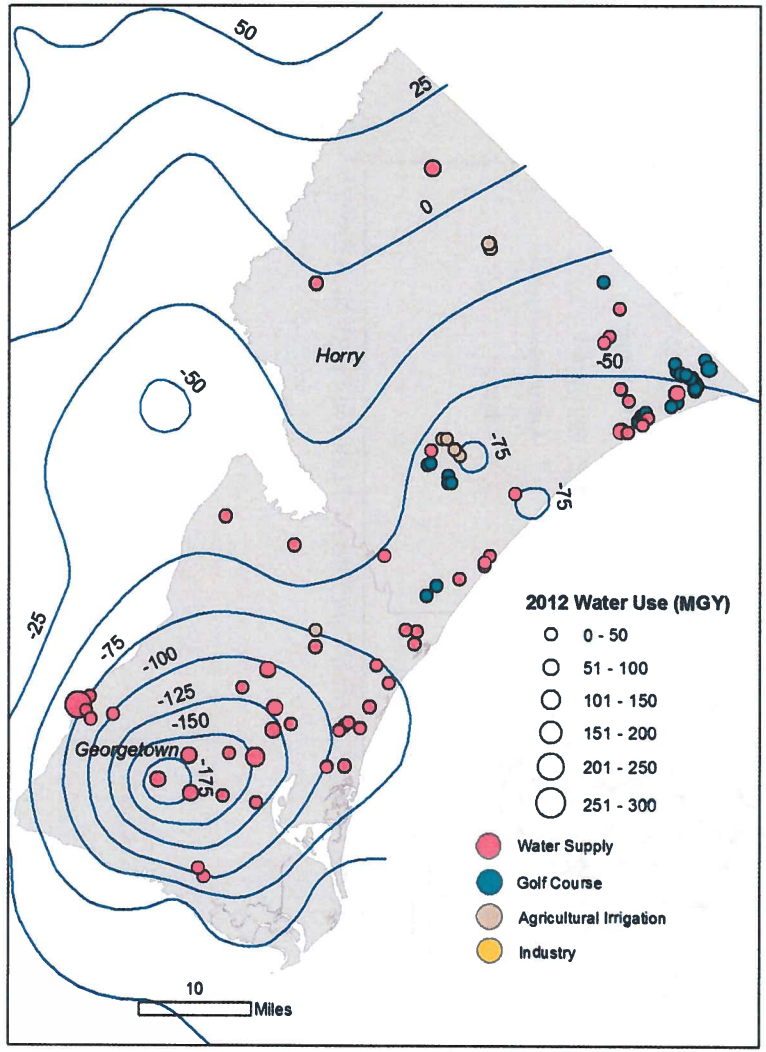


Figure 17: 2012 Reported Water Use and Equipotential Lines in the Crouch Branch aquifer.

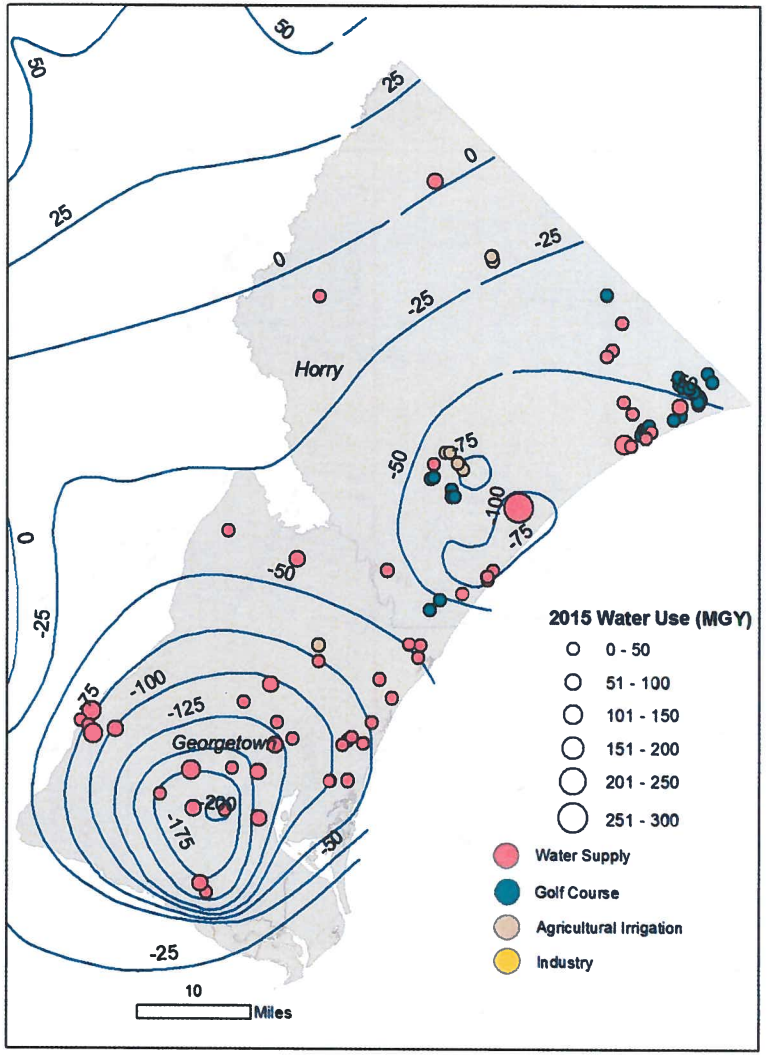


Figure 18: 2015 Reported Water Use and Equipotential Lines in the Crouch Branch aquifer.

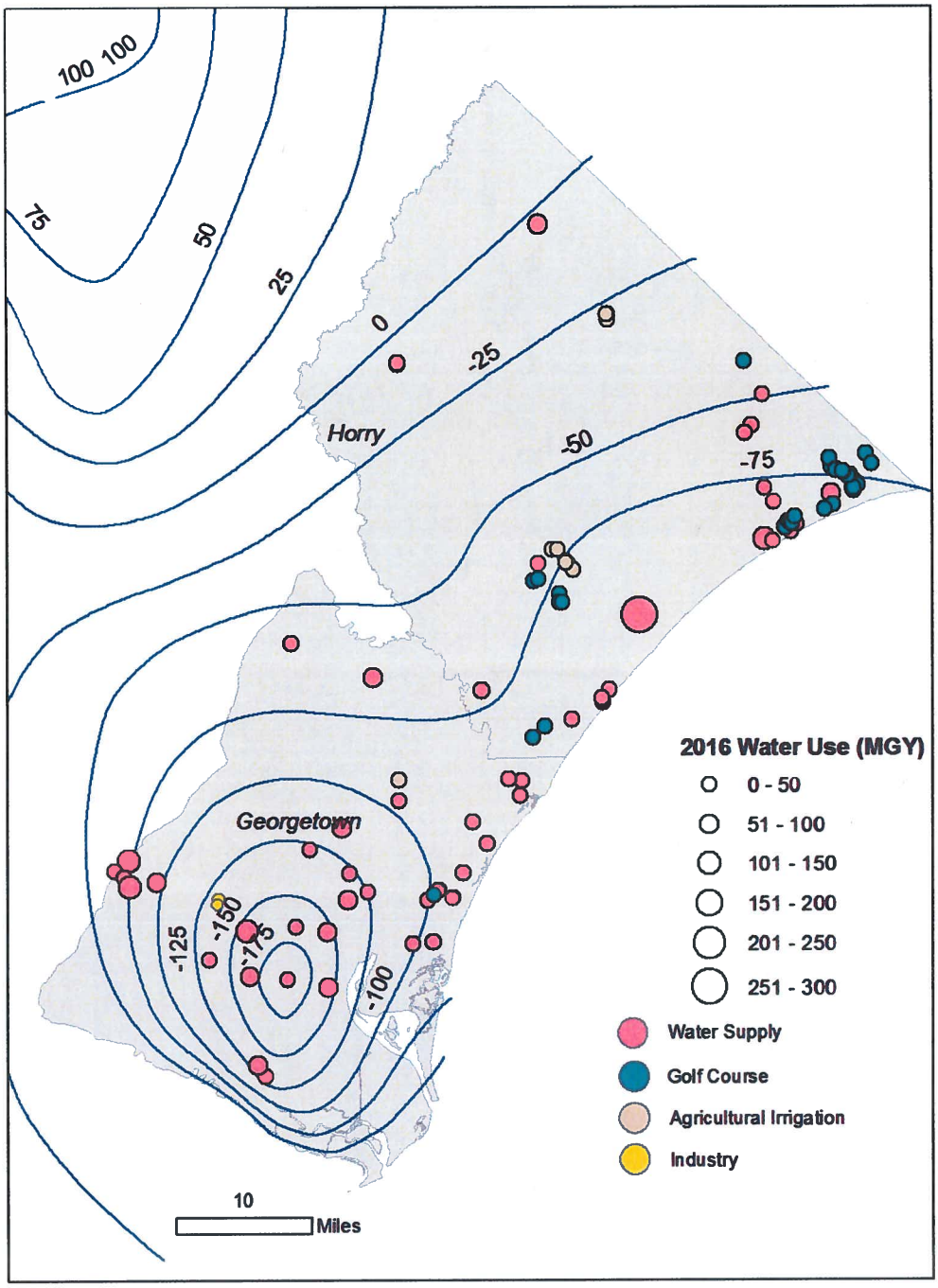


Figure 19: 2016 Reported Water Use and Equipotential Lines in the Crouch Branch aquifer.

Groundwater Evaluation

The Crouch Branch aquifer below the Waccamaw Area is stressed. This is evidenced by the measurements of declining water levels of up to 100 feet (Fig. 7) and the ongoing development of the cone of depression in Georgetown County. Both of these lines of evidence point to an aquifer that is being over-pumped. Excess withdrawal of groundwater in coastal portions of an aquifer can lead to three unwanted consequences: salt water intrusion, land subsidence and an associated increase in flooding events, and dry wells.

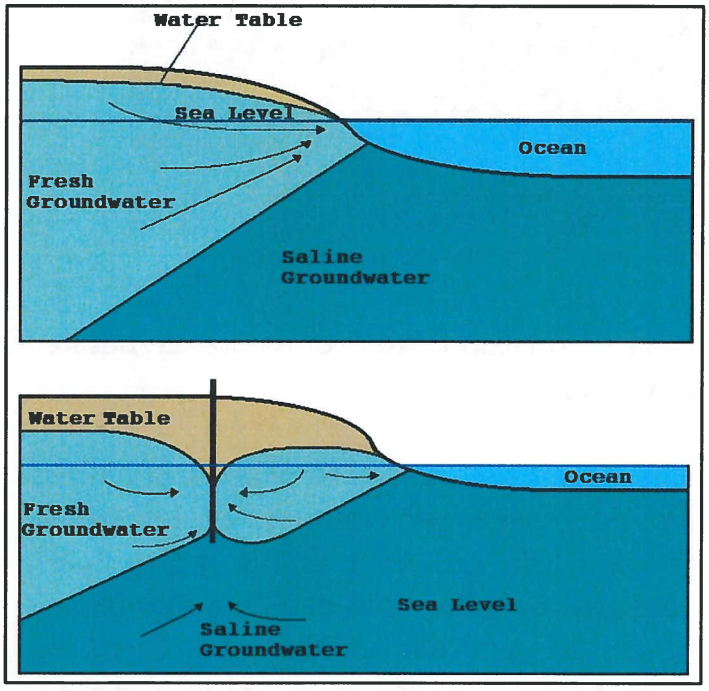


Figure 20: General Illustration of Salt Water Intrusion Mechanism in a Coastal Aquifer.

The reasons for the establishment of the Waccamaw Area included the intrusion of salt water into wells in the North Myrtle Beach area of Horry County and declining water levels in monitoring wells[5]. This occurred when pumping cones developed around wells that allowed for the freshwater/salt water boundary in the aquifer to move toward the wells and for the entry of salty water to those wells (Fig. 20). Salt water intrusion into a fresh water well means that water from that well is unusable for its intended purpose, whether drinking water, irrigation, or industry. Salt water intrusion increases the cost of using water from a compromised well through additional water treatment steps prior to use.

When several large-volume wells are in close proximity in a single aquifer, the combined drawdown exceeds that of a single well (Figs. 14 and 21). In the case of the Crouch Branch aquifer below the Waccamaw Area, the combined pumping of many wells has resulted in the development, broadening, and deepening of the cone of depression below Georgetown County, as illustrated in Figures 15 through 19. As discussed previously, this pumping depression has begun to impact the measured water levels in nearby counties (Fig. 19). At the present rate of pumping and

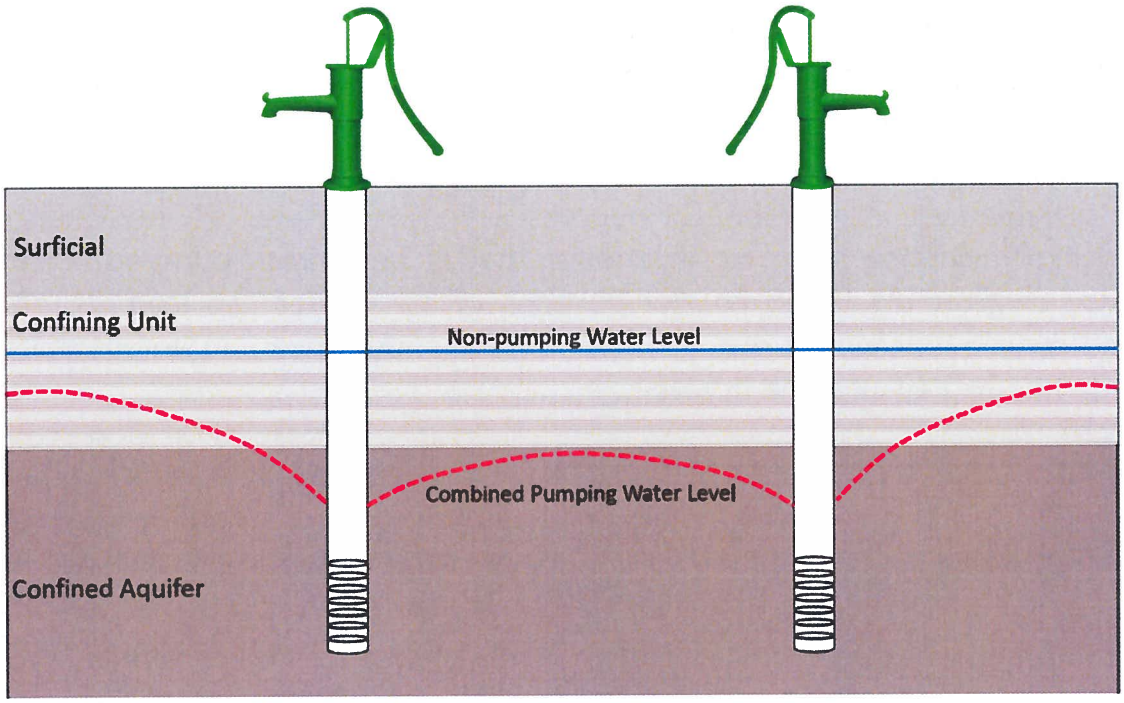


Figure 21: Illustration showing the combined drawdown effect of wells pumped in close proximity to one another.

distribution of wells, the potential for saltwater intrusion into Crouch Branch aquifer wells near the coast in Georgetown County is high.

The coastal plain aquifers of South Carolina (Fig. 3) are comprised of unconsolidated sediments. Groundwater is found in the spaces between sediment grains. When large amounts of groundwater are removed, the sediment grains move closer together (or compact) resulting in land subsidence. In the southern Chesapeake Bay area, land subsidence of up to 4.8 millimeters per year (mm/yr) has been associated with large groundwater withdrawals[6]. In North Carolina and South Carolina, subsidence due to geologic processes is being exacerbated by large volume groundwater withdrawals[7]. As the land sinks and sea level continues to rise[8,9], South Carolina will experience increased occurrences of coastal flooding.

An additional reason for the establishment of the Waccamaw Area was the occurrence of "dry" wells. A dry well may still have water, but the water level may now remain consistently below the pump intake because combined drawdown has lowered the overall water level in the aquifer. A dry well may also occur when the water level in the aquifer has fallen below the bottom of an existing well. When a well runs dry, the owner may have to lower the pump or pump intake to a point below the new water level. If the water level in an aquifer has fallen below the depth of the well-bottom, then the existing well will need to be deepened, or a new, deeper well

drilled. Both of these options leave the owner without water in the interim and result in additional expense. As water levels in the Waccamaw Area continue to decline, well owners will be left pursuing deeper and deeper water levels.

Recommendations

In order for the demonstrated cone of depression to recover and to protect the existing Waccamaw Area wells from the harmful effects discussed in the "Groundwater Evaluation" section, the following are the Department's recommendations.

1) Place a hold on the groundwater withdrawal rates for current permit holders in the Crouch Branch aquifer. When renewals are issued for 2019, no increases in groundwater withdrawal rates should be approved for wells screened in the Crouch Branch aquifer in either county.

2) No new wells that increase withdrawal rates should be permitted for construction and production in the Crouch Branch aquifer in Georgetown County. Based on the evidence that the Georgetown County cone of depression is affecting water levels in surrounding counties, the Department also recommends that no new Crouch Branch wells be constructed in Horry County. This hold on new well construction to the Crouch Branch aquifer should be kept in place until the Waccamaw Area undergoes its next 5-year review in 2024. At that time, the hold on new construction should be re-evaluated based on new water level information.

3) New Groundwater Withdrawal Permit Applications which propose to use the Crouch Branch aquifer should be diverted to the surficial, McQueen Branch, Charleston, or Gramling aquifers in Georgetown and Horry Counties as appropriate for the proposed use. It should be noted that groundwater from the McQueen Branch aquifer in the Waccamaw Area is not suitable for water supply due to its high Fluoride concentrations (ranging from 0.5 to 5.5 milligrams per liter[mg/L]) unless diluted with water from another source or defluoridated prior to use[10]. The current Public Health Service recommendation for Fluoride concentration in drinking water is 0.7 mg/L[11].

4) Encourage surface water as a source for future water demands. As stated in the Groundwater Demand section, water use reported for water supply in 2017 was only 1.9 times greater in Horry than Georgetown County while the population is

5.5 times greater. This is the result of Horry County's greater reliance on surface water sources. Also in 2017, Horry County reported using eight (8) times the amount of surface water for public water supply (17,163 MG) than Georgetown County (2,133 MG). Because the majority of Georgetown County's water supply wells are screened in the Crouch Branch aquifer, transitioning this demand to surface water sources would help alleviate the current over-pumping effects in this aquifer.

5) Conduct a targeted public education campaign on water conservation practices and the extent of the current over-pumping evidence. Targeted public education means that each campaign is designed for a particular segment of the population in the Waccamaw Area. For all water users from agriculture to industry to water suppliers to residents, it should include information on the broad range of water conservation methods available to them. It should be a requirement that all permitted withdrawers keep their Best Management Plan updated every 5 years on the same schedule as the permit renewals. Each segment of the public education campaign may even include public meetings with various stakeholders in both counties.

6) Each new and renewal permit for water supply wells should require that a water audit be conducted annually in accordance with the American Water Works Association policy statement for Water Loss Management, Metering and Accountability[12]

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